JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. V NOVEMBER 19, 1915 No. 19

ELECTRICITY.—*Protection of life and property against lightning.* O. S. PETERS, Bureau of Standards.

This paper is a report of a survey of statistical data relating to life and property hazards from lightning, and describes existing methods of protection against lightning. The field covered does not include electrical power and signal systems. In the course of preparation of the paper an examination was made of the available literature on the subjects of lightning phenomena and protection against lightning, and of the reports of fire marshals and insurance companies. In addition to this a considerable amount of data was obtained from the reports of the Census Bureau, and manufacturers of lightning rods were asked to submit their opinions, and the results of their experiences, as to how a system of lightning rods should be installed. Appendices are included in the complete paper, to be published by the Bureau of Standards, giving rules concerning the installation and maintenance of lightning rods which have in some cases been followed in Germany, England, and the United States, and also rules for first aid treatment in cases of persons injured by lightning.

The chief facts disclosed by the information obtained in the course of the inquiry may be summarized briefly as follows:

1. The property loss by lightning for the entire United States is approximately eight million dollars per year, of which by far the greater part occurs in rural districts.

2. During each year there are approximately 1500 persons affected by lightning stroke in the United States, one-third of this number being killed and the rest subjected to injuries which in many cases are permanent. About nine-tenths of these accidents occur in rural districts.

3. Such evidence as is available on the effectiveness of lightning rods indicates that, taking rods as they come in the general run of installations, they reduce the fire hazard from lightning by 80 to 90 per cent in the case of houses, and by as much as 99 per cent in the case of barns. The same is undoubtedly true of other buildings having characteristics similar to those of barns and houses.

4. With regard to the proper metal for lightning rods it may be said that the differences of resistivity of the metals ordinarily available for lightning rods are not great enough to make one metal preferable to another. Resistance to atmospheric and soil corrosion is the chief essential to be considered.

5. Extended metallic masses on or within a building must be made a part of the lightning rod system, with a possible exception, however, in the case of metallic masses within the building which do not come near the roof and are at a distance of ten feet or so from the rods. Gas pipes should be avoided in erecting lightning conductors if possible, but if they are so located that it is impossible to keep at a distance of ten feet or more, they should be electrically connected to the rods at several points, connected to earth within the building, and well bonded around the gas meter.

6. The maximum current in a lightning flash may, in some cases, be more than 20,000 amperes.

7. Each flash of lightning consists, in most cases at least, of a number of consecutive discharges along the same path with short time intervals between them. The duration of each of the consecutive discharges is of the order of 1/35000 second. The best obtainable evidence points to the fact that these consecutive discharges are unidirectional and of steep wave front.

8. The heating effects of a lightning stroke on a rod of ordinary size, i.e., a rod weighing about 0.5 kg. per meter, is not

likely to be appreciable except at the place where the stroke enters the rod, or at high resistance joints.

9. Good mechanical construction in a lightning rod system is a prime essential to permanency. Rods are subject to severe strains from wind, snow and ice, thermal expansion and contraction, and, in the event of a stroke of lightning, to electromagnetic stresses, so joints must be strong and the rod securely fastened to the building.

10. The resistance of the earth connection should be made as low as practicable. In practice there is no chance of getting too low a resistance. On the other hand, a resistance which rises above 15 or 20 ohms at any time should be considered as excessively large on account of the potential drop which may possibly be set up in the event of a stroke.

11. When a system of lightning rods is installed aerial terminals with points should be placed at all chimneys, gables, points or other projections toward which a stroke of lightning might be directed. This is necessary because a point cannot be relied upon to protect objects other than that upon which it is placed.

12. Down conductors should be run in such a way that a stroke on any aerial terminal on a structure will have two or more widely separated paths from the foot of the aerial terminal to earth. One path to earth has been found to be unsafe, and more than two are preferable.

13. It has been shown photographically that the path of a lightning discharge may be shifted by the wind as much as 10 meters or more during the period between the initial and final discharge. For this reason it is advisable not to allow too great an expanse of flat roof to be exposed without aerial terminals.

14. The return on an investment in lightning rods may be expected in two ways; in a sense of personal security from lightning, and in actual security to life and property. The property loss from lightning is not sufficient to cause universal protection against lightning to be a paying investment. Protection against lightning is justified as an investment only where risk to human life is involved, or where the property risk is great enough to make protection against lightning more economical than insurance.

15. With regard to personal safety from lightning it may be said that no place to which a person may ordinarily retire can be considered as absolutely safe. The only places which can be considered as closely approximating absolute safety are in a building completely surrounded by a metal network, in a steel frame building, or in an underground chamber. A high degree of safety, however, may be found in a well rodded building; the next degree of safety is undoubtedly to be found in an unprotected house which may be considered as far preferable to the open or to unprotected outbuildings.

BOTANY.—*Notes on Orthopterygium huaucui.* PAUL C. STANDLEY, U. S. National Museum.[1]

In 1907 Mr. W. Botting Hemsley published[2] a very elaborate account of a proposed new family of plants, the Julianiaceae, including two genera, *Juliania* (or *Amphipterygium*) and *Orthopterygium*, the latter being described as new. The family is a very remarkable one in many respects, and for a long time after the description of the first published species, *Juliania adstringens*, in 1843, its proper taxonomic position was unknown. Some authors placed *Juliania* in the Burseraceae or in the Anacardiaceae, while others referred it to the list of "genera incertae sedis." Hemsley, however, demonstrated that while the Julianiaceae bear certain resemblances to the Anacardiaceae, their affinities are rather with the Juglandaceae and Fagaceae.

The genus *Juliania* is an exclusively Mexican group, composed of four species, while *Orthopterygium* consists of a single Peruvian species, *O. huaucui*, the type specimens having been collected by the Wilkes Exploring Expedition "in the vicinity of Yanga, Peru," near Lima.[3] Specimens of the same plant had been collected, however, as early as 1831, on "the sides of the base of the Cuesta of Purruchuca, Province of Canta, Peru," by Mathew.

These two localities were the only ones known to Hemsley when his monograph of the family was prepared. Recently Dr. C. H.

[1] Published by permission of the Secretary of the Smithsonian Institution.
[2] Phil. Trans. Roy. Soc., London, Ser. B. **199**: 169–197, pl. 18–24.
[3] A. Gray in Wilkes, U. S. Expl. Exped. **15**: 371. 1854.

T. Townsend, of the U. S. Department of Agriculture, who has spent several years in entomological work in Peru and Ecuador, presented to the National Museum a small collection of plants from western Peru. Among the specimens are staminate flowers and nearly mature fruit of *Orthopterygium huaucui*. The fruit agrees perfectly with that of the type collection of the species.

Fig. 1. *Orthopterygium huaucui* in Chosica Canyon. The largest individual seen, a pistillate tree with fruits pendent from the branches.

Dr. Gray states that his own material consisted of "two leafless branches . . . . with nothing besides a terminal fascicle of immature, pendent, samaroid fruits." One of these branches is in the National Herbarium.

Dr. Townsend's specimens come from the general region of the two localities cited above. They were collected June 6 or 7,

1914, at an altitude of about 1800 meters at Goatherd Camp, Chosica Canyon, in the mountains northwest of the town of Chosica, Peru. The soil here consists of gravel and rock detritus. Soil and atmospheric humidity are practically nothing in the cool season, which extends from May to December. At this period the temperature is from 70 to 75°F. during the day, and 60 to 65° at night, the lowest temperature being probably not under 45°. In the warm season, lasting from January to April, there is a precipitation of perhaps 4 to 6 inches. The vegetation is very scanty, being confined to 3 species of columnar *Cereus* and a few shrubs and composites in the bed of the canyon. The animal life, likewise, is limited, only a few arid forms of vertebrates and insects being present.

Orthopterygium forms an extensive patch on a north slope near the top of the bench in the south side of the canyon, being scattered over an area several hundred yards in diameter, many of the trees lying dead on the summit of the northwest exposure of the bench. The plant is a shrub or small tree, 1 to 2.5 meters high, with spreading, brittle, "fat" twigs and branches having a milky latex. It was not in leaf the first of June, but the staminate flowers were present, dark red and pendent, as well as the green or reddish, pendent fruits.

The flowers received by the National Herbarium agree in every respect with those illustrated in Hemsley's monograph. The fruits are 6 to 7 cm. long, 11 to 16 mm. wide, and slightly pubescent. Like those of *Juliania* they are of a very curious structure; the pedicel becomes in age broad and flat and somewhat spongy, and sunken in its apex is borne the involucre which incloses the three flowers. The whole has the appearance of some samaroid fruit inverted, and the casual observer of the detached fruits might easily take the terminal involucre for a basal point of attachment.

The fruits of Dr. Townsend's specimens are so nearly mature as to show the characters of the seeds, which were not known before. Of the three ovaries in each involucre only one develops. The seed is pendent, attached laterally near the apex; it is strongly compressed, in outline narrowly ovate-acuminate, taper-

ing gradually from the base to the apex; it is 11 to 12 mm. long, 3.5 mm. broad, and 1.5 mm. thick; the radicle is slender and ascending; the cotyledons are thin and very brittle; the testa is membranous and pale brown.

The illustration showing habit and habitat is from a photograph kindly furnished by Dr. Townsend, who has supplied also the geographic and habital data given above.

TECHNOLOGY.—*Standard zinc-bronze: Relation of micro-structure and mechanical properties.* HENRY S. RAWDON, Bureau of Standards.[1]

To complete the study of the mechanical properties of zinc-bronze (Cu 88, Sn 10, Zn 2) as influenced by the method of casting, temperature of pouring, and other varying factors of foundry practice, a detailed study of the micro-structure of a large number of test bars was made. The results show that the method of preparation affects the structure only indirectly by the rate of cooling, amount and distribution of foreign inclusions, etc.

In the cast condition the alloy consists of an aggregate of relatively large crystals, each of which comprises a dendritic matrix consisting of a solid solution of tin (and zinc?) in copper, embedded in which are numerous particles of a hard brittle eutectoid. When stress is applied and continued beyond the "elastic limit," the matrix is plastically deformed while the eutectoid enclosures are shattered and broken transversely across. When broken in the tension test, the bars become wrinkled and roughened in a characteristic manner which is to be attributed to the orientation of the crystal-structure and properties. The examination of a good many broken bars shows that, with few exceptions, when fracture occurs it takes place within the crystals and is not a mere pulling apart and separation of adjacent crystals.

Since the fracture occurs through the crystals, i.e., along cleavage planes, rather than between them, the size of crystals is an important factor in determining the ultimate strength of

[1] To appear in full as a Technologic Paper of the Bureau of Standards.

the tensile bar. The crystals after slow cooling are relatively large and instances were found where the fracture occurred at a point where one crystal extended across the greater portion of a cross-section of the bar and thus determined the mechanical properties of the whole sample. Often, adjacent crystals are very similarly oriented and, mechanically, are practically equivalent to a single crystal. In ordinary sand castings, however, such cases are apparently unavoidable.

Of all possible factors affecting the tensile strength the presence of oxides in the form of pits and films is especially serious. The following illustrates the deleterious effect of such oxide films:

No. of specimens examined.	*No. found containing oxide films.*	*Ultimate tensile strength per sq. in.*
13	13	30,000 lbs. or less
12	10	30,000 to 35,000

In test-bars showing a tensile strength above 35,000 pounds per square inch, oxide films were rarely found and then only in small isolated spots.

The presence of oxides of tin and zinc in the form of pits and films may be considered, then, as the predominating factor in the cause of mechanical weakness of cast bronze.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOPHYSICS.—*The Earth's magnetism.* L. A. BAUER. Ann. Rep. Smithsonian Institution for 1913, pp. 195–222, 9 pls. 1914. (Smithsonian Inst. Pub. 2281.)

The fourth "Halley Lecture," delivered in the schools of the University of Oxford on May 22, 1913; reprinted, after revision by the author and with additional illustrations, from Bedrock, vol. 2, no. 3, October, 1913, pp. 273–294. The lecture concerns itself especially with Halley's contributions to terrestrial magnetism, to recent advances relating primarily to the mapping of the Earth's magnetic field at any one time, and to the determination of the secular changes. Among the illustrations are a portrait of Halley, a view of the house occupied by Halley while living at Oxford, and a reduced facsimile reproduction of Halley's first chart of the lines of equal magnetic declination as based on his observations in the Atlantic Ocean during the cruises of the *Paramour Pink*, 1698–1700. In the closing paragraph the belief is expressed that a long step forward will have been taken toward the discovery of the *origin* of the Earth's magnetism when once we have found out the causes of its many, and often surprising, variations. As some slight indication of the import the solving of the riddles of the Earth's magnetism may be, Schuster's suggestive remark is recalled that "atmospheric electricity and terrestrial magnetism, treated too long as isolated phenomena, may give us hints on hitherto unknown properties of matter." J. A. F.

GEOLOGY.—*Guide book of the Western United States, Part C. The Santa Fé Route.* N. H. DARTON and others. U. S. Geological Survey Bulletin 613. Pp. 194, maps and illustrations. 1915. (For sale by the Supt. of Public Documents, Washington, D. C. Price $1.)

The average busy American is prone to regard the journey across the Great Plains of the Middle West and the arid stretches of New Mexico and Arizona, as an enforced tedium to be mitigated as far as possible by slumber, magazines, or the "smoker." Only some unusually picturesque feature stirs him to a real interest in his surroundings. Travel for the purpose of understanding the country traversed rather than as a means of getting from city to city is an art less developed here than abroad. The purpose of this guide book of the Santa Fé Route is to make the 1800 miles between Kansas City and Los Angeles interesting and educating to the intelligent traveler, by explaining in non-technical language the meaning of the things that are visible from the car window. Emphasis is placed upon the meaning of the scenic features of the landscape, as is natural in a publication emanating from the Geological Survey, but many features of agricultural or of botanical interest, such as the peculiar floral features of the desert, are also described, and the history of human endeavor in the "winning of the west" receives a just share of attention.

The explanation of such striking natural features as the petrified forest in Arizona, the volcanic cones near Winona, Arizona, and greatest of all, the Grand Canyon, will be particularly welcomed by travelers. Of great human interest are the descriptions and pictures of Hopi and Navajo Indian villages of the "Painted Desert." The journey through some of the less picturesque regions is enlivened by excursions into the geologic past whose gigantic reptiles are pictured from authoritative restorations by Charles R. Knight. E. S. BASTIN.

GEOLOGY.—*The fractional precipitation of some ore-forming compounds at moderate temperatures.* ROGER C. WELLS. U. S. Geological Survey Bull. 609. Pp. 46. 1915.

The experiments described in this bulletin were made to aid in elucidating the chemistry of ore deposition. They yield as their immediate result the order of solubility of the compounds of each of the classes investigated—sulfides, hydroxides, carbonates, and silicates. The results with the silicates are really those due to hydroxides, since the silicates are so completely hydrolyzed in aqueous solution,

but they show that metallic bases are incapable of removing silica from solution completely. The work of Anthon and Schürmann, which covered the sulfides fairly completely, is discussed in order to compare their results with the solubilities and solubility products determined by physicochemical methods. The order of solubility of sulfides obtained from experiments on fractional precipitation agrees better with solubility products calculated from electromotive force measurements than it does with Weigel's results obtained by conductivity determinations. Incidentally, it is shown that the immediate precipitate produced by alkaline sulfides and copper salts contains a much higher proportion of cuprous sulfide than that formed by hydrogen sulfide in acid solutions. The precipitation series obtained for the hydroxides, beginning with the most insoluble, is as follows: Ferric, aluminium, cupric, zinc, lead, nickel, silver, ferrous, manganous, magnesium, calcium. The series obtained for carbonates, based on results with sodium bicarbonate as precipitant, is: Mercury, lead, cadmium, manganese, silver, ferrous, zinc, calcium, magnesium.

R. C. W.

FORESTRY.—*Value of the big tree contest.* W. H. Lamb. The Journal of Heredity, **6**: 424–428. 1915.

This is a discussion of the scientific value of the prize photograph contest conducted by the American Genetic Association, in which the largest hardwood tree discovered was a sycamore (*Platanus occidentalis*), located at Worthington, Indiana, which measures 42 feet 3 inches in circumference and about 140 feet in height. In this contest the interest of the forester and the dendrologist centered upon the ascertainment of the species reaching the maximum size, the greatest size attained by every species, and upon consideration of the geographic location of notable trees with respect to their natural range. In discussing the contest from this viewpoint, data are presented upon the influence of heredity and environment upon the form and size of trees, on the doctrine of indefinite longevity in trees, and on the scientific and aesthetic value of large specimens. Maps are included showing the natural range and location of the largest individuals of six important timber trees, and attention is called to the desire of the Association for information on the location, life history, and size of notable trees throughout the United States.

W. H. L.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

GEOLOGY

BASTIN, EDSON S. *Ores of Gilpin County, Colorado.* Economic Geology, **10:** 262–291, pl. 12, figs. 40–42. 1915.

BAUER, C. M. *A sketch of the late Tertiary history of the Upper Missouri River.* Jour. Geol. **23:** 52–58, fig. 1. 1915.

BUTLER, B. S. *Geology and ore deposits of the San Francisco and adjacent districts, Utah.* Economic Geology, **9:** 413–434, 529–558, pl. 5, figs. 109–110, 124–129. 1914.

BUTLER, B. S. *Relation of ore deposits to different types of intrusive bodies in Utah.* Economic Geology, **10:** 101–122, figs. 16–19. 1915.

CAPPS, S. R. *Some ellipsoidal lavas on Prince William Sound, Alaska.* Jour. Geol. **23:** 45–51, figs. 1–5. 1915.

CLARKE, F. W. *Analyses of rocks and minerals from the laboratory of the United States Geological Survey, 1880 to 1914.* U. S. Geological Survey Bulletin 591. Pp. 376. 1915.

DILLER, J. S. *The eruptions of Lassen Peak, California.* Bull. Seismological Soc. Amer. **4:** 103–107. 1914. Also, The Mazama, **4:** 54–59, Illustrated. 1914.

FATH, A. E. *Copper deposits in the "Red Beds" of southwestern Oklahoma.* Economic Geology, **10:** 140–150, figs. 22–27. 1915.

FERGUSON, HENRY G. *Pocket deposits of the Klamath Mountains, California.* Economic Geology, **10:** 241–261, pl. 11, figs. 30–39. 1915.

KNOPF, ADOLPH. *Is the boulder batholith a laccolith? Discussion of a paper by A. C. Lawson.* Economic Geology, **9:** 396–402. 1914.

LEE, W. T. *Relation of the Cretaceous formations to the Rocky Mountains in Colorado and New Mexico.* U. S. Geological Survey Professional Paper 95-C, pp. 13–26, pls. 1–4, figs. 2–11. 1915.

LOUGHLIN, G. F. *The oxidized zinc ores of the Tintic district, Utah.* Economic Geology, **9:** 1–19, pls. 1–2, figs. 1–8. 1914.

PALMER, CHASE. *Studies in silver enrichment. Tetranickel-triarsenide, its capacity as a silver precipitant.* Economic Geology, **9:** 664–674. 1914.

POGUE, J. E. *The Cantwell formation. A continental deposit of Tertiary age in the Alaska Range.* Jour. Geol. **23:** 118–128, figs. 1. 1915.

ROGERS, G. S., and LESHER, C. E. *The use of thickness contours in the valuation of lenticular coal beds.* Economic Geology, **9:** 707–729, pls. 16–18. 1914.

SIEBENTHAL, C. E. *Spring deposits at Sulphur Springs, Arkansas.* Economic Geology, **9:** 758–767. 1914,

UMPLEBY, JOSEPH B. *The genesis of the Mackay copper deposits, Idaho.* Economic Geology, **9**: 307–358, figs. 80–89. 1914.

WEGEMANN, C. H. *Anticlinal structure in parts of Cotton and Jefferson Counties, Oklahoma.* U. S. Geological Survey Bulletin 602. Pp. 108, 5 plates. 1915.

ENGINEERING

BABB, C. C., COVERT, C. C., and MATHERS, J. G. *Surface water supply of the north Atlantic coast basins, 1912.* U. S. Geological Survey Water-Supply Paper 321. Pp. 240. 1914.

ELLSWORTH, C. E., and DAVENPORT, R. W. *Surface water supply of the Yukon-Tanana region, Alaska.* U. S. Geological Survey Water-Supply Paper 342. Pp. 343. 1915.

FOLLANSBEE, ROBERT. *Surface water supply of the lower Mississippi River basin.* U. S. Geological Survey Water-Supply Paper 327. Pp. 84. 1914.

FOLLANSBEE, ROBERT, and DEAN, H. J. *Water resources of the Rio Grande basin, 1888-1913,* including *Surface water supply of the western Gulf of Mexico basins, 1913,* by ROBERT FOLLANSBEE, W. W. FOLLETT, and G. A. GRAY. U. S. Geological Survey Water-Supply Paper 358. Pp. 725. 1914.

FOLLANSBEE, ROBERT, and GRAY, G. A. *Surface water supply of lower Mississippi River basin, 1913.* U. S. Geological Survey Water-Supply Paper 357. Pp. 86. 1915.

FOLLANSBEE, ROBERT, PORTER, E. A., and PADGETT, H. D. *Surface water supply of the Colorado River basin, 1912.* U. S. Geological Survey Water-Supply Paper 329. Pp. 238. 1914.

FOLLETT, W. W., FOLLANSBEE, ROBERT, and GRAY, G. A. *Surface water supply of the western Gulf of Mexico basins, 1912.* U. S. Geological Survey Water-Supply Paper 328. Pp. 121. 1914.

HENSHAW, F. F., BALDWIN, G. C., STEVENS, G. C., and FULLER, E. S. *Surface water supply of the north Pacific coast basins, 1911.* U. S. Geological Survey Water-Supply Paper 312. Pp. 706. 1915.

HENSHAW, F. F., and FULLER, E. S. *Surface water supply of the north Pacific drainage basins, Lower Columbia River and Rogue, Umpqua, and Siletz rivers.* U. S. Geological Survey Water-Supply Paper 332-C. Pp. 226. 1914.

HENSHAW, F. F., LEWIS, JOHN H., and MCCAUSTLAND, E. J. *Deschutes River, Oregon, and its utilization.* U. S. Geological Survey Water-Supply Paper 344. Pp. 200. 1914.

HENSHAW, F. F., PORTER, E. A., and STEVENS, G. C. *Surface water supply of the Great Basin.* U. S. Geological Survey Water-Supply Paper 330. Pp. 275. 1915.

HORTON, A. H., HALL, W. E., and JACKSON, H. J. *Surface water supply of the Ohio River basin, 1912.* U. S. Geological Survey Water-Supply Paper 323. Pp. 118. 1914.

HORTON, A. H., HOYT, W. G., and JACKSON, H. J. *Surface water supply of the upper Mississippi River and Hudson Bay basins, 1912.* U. S. Geological Survey Water-Supply Paper 325. Pp. 193. 1914.

HORTON, A. H., HALL, W. E. and PETERSON, H. J. *Surface water supply of Ohio River basin, 1913.* U. S. Geological Survey Water-Supply Paper 353. Pp. 264. 1915.

HOYT, W. G., HORTON, A. H. and COVERT, C. C. *Surface water supply of St. Lawrence River basin, 1913.* U. S. Geological Survey Water-Supply Paper 354. Pp. 136. 1915.

LAMB, W. A., FOLLANSBEE, ROBERT, and PADGETT, H. G. *Surface water supply of the Missouri River basin, 1912.* U. S. Geological Survey Water-Supply Paper 326. Pp. 375. 1914.

LAMB, W. A., and FOLLANSBEE, ROBERT. *Surface water supply of Missouri River basin, 1913.* U. S. Geological Survey Water-Supply Paper 356. Pp. 291. 1915.

MCGLASHAN, H. D., and STEVENS, G. C. *Surface water supply of the Pacific coast basins in California, 1912.* U. S. Geological Survey Water-Supply Paper 331. Pp. 442. 1914.

MARSHALL, R. B. *Profile surveys in the basin of Clark Fork of Columbia River, Montana-Idaho-Washington.* U. S. Geological Survey Water-Supply Paper 346. Pp. 6. 1914.

MARSHALL, R. B. *Profile surveys in Snake River Basin, Idaho.* U. S. Geological Survey Water-Supply Paper 347. Pp. 12. 1914.

MARSHALL, R. B. *Profile surveys in Hood and Sandy River basins, Oregon.* U. S. Geological Survey Water-Supply Paper 348. Pp. 8. 1914.

MARSHALL, R. B. *Results of spirit leveling in Michigan, 1911 and 1913.* U. S. Geological Survey Bull. 559. Pp. 79. 1915.

MARSHALL, R. B. *Results of spirit leveling in Minnesota, 1897 to 1912, inclusive.* U. S. Geological Survey Bull. 560. Pp. 190. 1915.

MARSHALL, R. B. *Results of spirit leveling in Hawaii, 1910 to 1913, inclusive.* U. S. Geological Survey Bull. 561. Pp. 42. 1914.

MARSHALL, R. B. *Results of spirit leveling in Virginia, 1900 to 1913, inclusive.* U. S. Geological Survey Bull. 562. Pp. 68. 1914.

MARSHALL, R. B. *Results of spirit leveling in Maryland, 1896 to 1911, inclusive.* U. S. Geological Survey Bull. 563. Pp. 80. 1915.

MARSHALL, R. B. *Results of spirit leveling in Colorado, 1896 to 1914, inclusive.* U. S. Geological Survey Bull. 565. Pp. 192. 1915.

MARSHALL, R. B. *Results of spirit leveling in Utah, 1897 to 1914, inclusive.* U. S. Geological Survey Bull. 566. Pp. 77. 1915.

MARSHALL, R. B. *Results of spirit leveling in Idaho, 1896 to 1914, inclusive.* U. S. Geological Survey Bull. 567. Pp. 130. 1915.

MARSHALL, R. B. *Results of spirit leveling in Missouri, 1896 to 1914, inclusive.* U. S. Geological Survey Bull. 568. Pp. 219. 1915.

MARSHALL, R. B. *Results of spirit leveling in Iowa, 1896 to 1913, inclusive.* U. S. Geological Survey Bull. 569. Pp. 126. 1915.

MARSHALL, R. B. *Results of spirit leveling in Wisconsin, 1897 to 1914, inclusive.* U. S. Geological Survey Bull. 570. Pp. 86. 1915.

MARSHALL, R. B. *Results of spirit leveling in Nebraska, 1896 to 1913, inclusive.* U. S. Geological Survey Bull. 572. Pp. 57. 1915.

MARSHALL, R. B. *Results of spirit leveling in Arizona, 1899 to 1915, inclusive.* U. S. Geological Survey Bull. 573. Pp. 123. 1915.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 759th meeting was held at the Cosmos Club, on October 2, 1915. President Eichelberger in the chair, 70 persons present.

Mr. W. F. G. Swann presented a paper on *The normal electric field of the Earth*. The first portion of the paper dealt with the causes responsible for the ionization of the atmosphere. The radio-active material in the air over the sea is not sufficient to account for the ionization observed, but the measured value of the penetrating-radiation is amply sufficient to make up for the deficit. Over the land the active material in the air above is sufficient to account for more than the ionization *ordinarily observed*, so that there is a surplus to account for the existence of a large number of the so-called "Langevin ions."

The second portion of the paper dealt with the maintenance of the Earth's charge. It was shown, on theoretical grounds, that the assumption of a continual return conduction current over some region of the Earth is untenable. Any theory which accounts for the maintenance of the Earth's negative charge by the entrance of negative corpuscles from regions outside the atmosphere, will, in virtue of the known increase of conductivity with altitude, automatically account for the positive charge in the atmosphere.

It was explained that if any theory is adopted in which the negative charge on the Earth comes in some way from the atmosphere, and in which the replenishment is confined to a limited region or time, then, on such a theory it is necessary to assume a state of very high conductivity in the upper atmosphere in order to account for the existence of atmospheric-electric phenomena at places where the replenishment is absent.

The part played by the electrical convection current was considered, and it was explained that any attempt to account for a balance of the conduction current by this agency would result in the conclusion that all atmospheric-electric phenomena should be located within a shell of comparatively small altitude.

The significance of the variation of the vertical conduction current with altitude was discussed, and it was pointed out that such variations indicate a passage of electricity into and out of the volume-elements of the air partly by processes other than conduction. A provisional hypothesis as to a corpuscular emission from the atmosphere was cited, by the help of which such variations in the vertical conduction

may be accounted for, and the origin and maintenance of the Earth's charge itself explained.

The paper was discussed by Messrs. OLSHAUSEN, BAUER, HUMPHREYS, and DELLINGER.

Mr. J. W. HUMPHREYS then presented a paper on *Lightning discharges* illustrated with lantern slides. The electric separation essential to the lightning discharge is produced, according to Simpson's well supported theory, by the disruption of rain drops in the air and the transfer of the resulting negative spray to higher altitudes by convection currents. But however produced, when the potential-gradient between different portions of the cloud, or between the cloud and the earth, has anywhere reached the disruptive value, lightning immediately occurs.

When seen at close range lightning appears as a sinuous line or streak of vivid white or, occasionally, pink—sinuous because, presumably, of irregular ionization and consequent irregular conductivity of the atmosphere. Some of these discharges are single, as shown by rotating cameras, and of short duration, while many are multiple, consisting of a number of partial discharges generally of unequal strength and at irregular intervals, but all following the same path, the ionized and therefore conducting path of the first discharge. Occasionally a streak of lightning persists a full second or even longer, gradually fading away, and thus producing, through its end-on and therefore brighter portions, the phenomenon known as beaded or pearl lightning.

Sheet lightning, so often seen in distant cumuli, presumably is only the diffused and reflected light of ordinary streak lightning. The objective reality both of rocket or slow moving lightning and of ball lightning is often doubted, but both have the support of many excellent observers.

It is commonly stated that the lightning discharge consists of many high frequency oscillations. A close examination of the evidence however indicates that it is either unidirectional or else very heavily damped. But little is known of the maximum current strength in a lightning discharge, though there is evidence sufficient, apparently, to show that this may amount to 10,000 amperes, perhaps even 100,000 amperes but that the quantity of electricity is surprisingly small, rarely enough to electrolyze 0.1 cc. of water.

The paper was discussed by Messrs. LITTLEHALES, OLSHAUSEN, AUSTIN, FRAZER, and SWANN.

F. E. WRIGHT, *Secretary pro tem.*

X